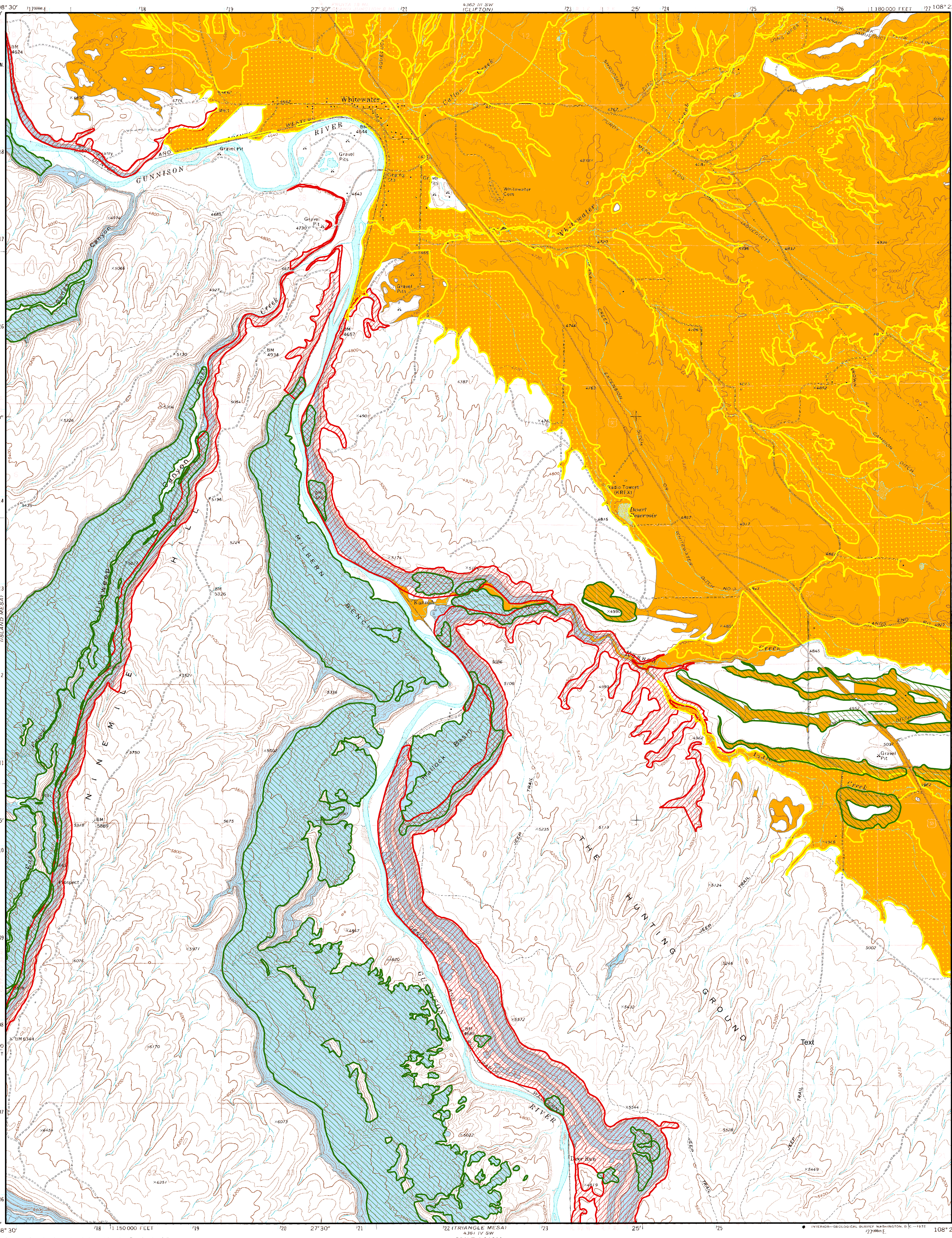
COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES
GOLDEN, COLORADO



Mapped, edited, and published by the Geological Survey

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Topography by photogrammetric methods from aerial photographs taken 1968. Field checked 1969

Polyconic projection. 1927 North American datum
10,000-foot grid based on Colorado coordinate system, central zone
1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue

Fine red dashed lines indicate selected fence lines

UTM GRID AND 1969 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

QUADRANGLE LOCATION

This derivative hazard map was created using data from the geologic map of the Whitewater quadrangle. The geologic map was funded jointly by the Colorado Geological Survey and the U.S. Geological Survey through the National Cooperative Geologic Mapping Program under STATEMAP agreement number G12AC20229. The hazard map was funded solely by the Colorado State Severance Tax Operational Fund.

Geologic hazards derivative map of the Whitewater quadrangle, Mesa County, Colorado

By
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GEOLOGIC-HAZARD DERIVATIVE MAP DISCUSSION

This map is a derivative map created from geologic mapping of the Whitewater Quadrangle, CGS open-file report #14-09 (White and others, 2014). The following hazards have been either mapped or identified: rockfall, landslides, and problematic soils and bedrock that have the potential to swell (expand) or subside (collapse or settle). More in-depth discussion of the following hazards can be found in the Authors Notes of the geologic map.

ROCKFALL

Rockfall hazards occur below the cliffs of the Gunnison River, East Creek, and Kannah Creek canyon rims, as well as some of the smaller canyons near Bangs Canyon. Most of the rockfall hazard locations occur on public property within the BLM Dominguez-Escalante National Conservation Area and are not shown on this derivative map. However, the public is exposed along State Highway 141 and private landholdings near the East Creek confluence and in the lower Kannah Creek/Indian Creek area. Many sections of the railroad tracks through Gunnison Canyon are also exposed to potential rockfall hazards.

LANDSLIDES

Landslides form in two general geomorphic conditions. The most extensively formed are very large ancient landslide complexes within the canyons of the Gunnison River and East, Bangs, and Kannah Creeks. There, the weak claystones of the Morrison Formation are exposed below the rim rocks and have failed, causing retrogressive toppling and slumping failures of the Dakota Sandstone and Burro Canyon Formation cap rock. For the most part, these landslides are ancient, activated when climatic conditions were wetter during Pleistocene glacial epochs. The broadest landslide complexes are on the west canyonsides where downcutting into the Uncompahgre Uplift has daylighted northeast-dipping bedding planes. For the future, the existing chaotic landslide rubble and sheared broken land is now even further weakened and prone to additional movements if they become saturated. There are reactivated areas of more recent landslides within these landslide complexes and loose material within drainage channels may be entrained into debris flows. Fortunately, impacts to private property are minimal because most of these landslides lie on public lands. State Highway 141 lies mostly on landslide deposits from about 1½ miles above the Gunnison River confluence where the Morrison Formation begins its exposure along the canyon floor. There is some private land exposure to this type of landslides in the lower Kannah Creek, near its confluence with the Gunnison River.

The second system is much smaller in area but more important since it lies on mostly private property. Smaller landslides and soil slips occur near Kannah Creek along mesa bluffs where Pleistocene gravel (Qak) caps high terrace remnants that are underlain by Mancos Shale. The gravel is permeable so water passes easily downward to the contact with the relatively impermeable shale. The perched groundwater migrates laterally to the mesa edge forming seeps in the slope. If the Mancos is sufficiently weakened and saturated, it shears and slips, forming small landslides. These types of landslides are very common along the Uncompahgre River valley where extensive irrigation occurs on mesas underlain by the Mancos Shale (White and others, 2011). New development should avoid the mesa edges where the underlying bedrock is the Mancos Shale.

PROBLEMATIC SOIL AND BEDROCK

Problematic soils and bedrock contain properties that cause volumetric changes, generally when they become wetted beyond their original natural condition. There are two basic mechanisms: Swelling or expansive soil and bedrock, and compactive (collapsible) or settling soil and bedrock. Problematic soils derived from shale bedrock can also be corrosive to certain metals and concrete. Subsurface soil investigations are recommended for foundation design of new construction in problematic soil areas. These investigations should include sampling and swell/consolidations testing that measure the swell or collapse potential of the load-bearing soils, as well has addressing the corrosive nature of the soil.

Swelling Soils

Swelling soil and expansive bedrock are: soil and rock that contain clay minerals that attract and absorb water (Rogers and others, 1974). The rock or soil swells in volume when wet and shrinks when dry. The swelling is caused by the chemical attraction of water to certain clay minerals, predominantly smectite and, to a lesser extent, illite. At the molecular level, clay minerals form micron-sized sheets or plates. Within the crystalline lattice of these clay minerals, layers of water molecules have an affinity to be incorporated between the clay plates. As more water is made available to the clay, more layers of water molecules are added between the plates and the adjacent clay plates are pushed farther apart. The overall soil-swell pressure from the addition of water at the molecular level can be quite high and can easily heave typical foundations and slabs, resulting in severely damaged structures (Noe, 2007).

The swelling of expansive-clay soil is a mineralogical phenomenon as available water is taken in and clay particles swell. Expansive soils can also shrink when desiccation occurs and the soil volume reduces as evaporation pulls water molecules out of the clay particles. The terms swelling soil, expansive soil and bedrock, heaving soil, and shrink-swell soils are used interchangeably to describe the mineralogical volume expansion process described above. Very commonly, repeated shrink-swell cycles in surface exposures of expansive-clay soil results in desiccation cracks and what is called “popcorn texture” commonly seen in the Mancos abode hills (White and others, 2011).

The major bedrock units that contain expansive clay minerals in the project area are the Mancos Shale and shales of the Morrison Formation. Most of the private property in the northeast corner of the map area near Whitewater and Kannah Creek is underlain by Mancos Shale, or sediment (soils) that are derived from it so there is highly probability that swelling clay minerals are present. Shales of the Morrison Formation are of lesser concern because they lay mostly on public lands of the BLM Dominguez-Escalante National Conservation Area, except for private lands in-holdings within Kannah Creek canyon near the confluence with the Gunnison.

Settling or collapsible soils and bedrock

Collapsible soils are broadly defined as soils that can rapidly settle when exposed to water. These soils can be a significant geologic hazard in semiarid to arid climates. The collapse can occur under the weight of the soil alone (overburden pressure) or under the additional load of a building or other structure. Most collapse occurs through mechanical means where dry, low-density, high-porosity soil becomes denser when the soil-particle binding agents weaken or break after wetting. The destruction and recompaction of the soil structure at moister conditions cause settlement of the ground surface. Because the introduction of water brings about such collapse, the terms “hydrocompactive” and “hydrocompressible” are commonly used to describe collapsible soils. Other processes of ground subsidence and collapse occur in certain soil and bedrock through (1) suspension and removal of particles in dispersive soil by flowing water (soil piping and pseudokarst formation) and (2) actual chemical dissolution of gypsiferous soils and secondary gypsum in Mancos Shale bedrock (White and Greenman, 2008).

Collapsible soil forms in specific, geologically recent (Holocene) sediments that have been deposited in arid to semiarid environments. In the Whitewater area those deposits are alluvial mud flows **(Qamf)** and finer-grained colluviums **(Qc)**: accumulations of rapidly deposited, unsorted, water-borne mud in alluvial and debris-flow fans. Where soil collapse can exist, an open and inherently unstable skeletal fabric characterizes the soil structure of these sediments. The common factor in the water-laid sediments is rapid deposition. In a generally arid climate, wet sediments quickly desiccate (dry out) in their original condition, without the benefit of further reworking to pack the sediment grains. Locally, groundwater levels generally never rise into these mantles of soil, which can remain unsaturated until land development. During and after development, moisture can be introduced to the subsurface soil through field irrigation, lawn and landscaping irrigation, capillary action under impervious slabs, leaking or broken water and sewer lines, and altered surface and subsurface drainage (White and Greenman, 2008).

The above definition states that soil collapse is a mechanical phenomenon as soil grains shear against each other, physically moving and re-orienting into a denser configuration, which results in a one-time reduction of soil volume. This is an important distinction from expansive soils that can experience repeated cycles of swelling and shrinking, depending on periods of wetting and desiccation.

Other processes of soil settlement and collapse can also present problems, as it does similar terrain in the Uncompahgre River valley in Montrose County (White and others, 2011). Dispersive soils have soil chemistry high in sodium-ion concentrations. This occurs because most of the mud-type alluvial sediments **(Qamf)** are derived from the Mancos Shale, which can have a high salt content. Other impacts of high salt content and high total-dissolved-solids content of the Mancos Shale and soils derived from it include corrosiveness and salt/selenium loading of irrigation waters. Soil dispersion occurs when clay particles deflocculate in the presence of water and go into suspension. Moving water flushes the suspended clay and silt away and soil pipes, fissures, and small caverns can open, generally near existing arroyos. Collapse of these types of features can form psuedokarst landforms such as sinkholes and ground fissures.

The dissolution of gypsum in weathered shale bedrock and soil can also result in ground settlement. Complex biogenic and oxidation-weathering chemistry results in the abundant gypsum fracture-filling observed in weathered zones of the Mancos Shale. Arid-climate soils can also by gypsiferous. In the presence of introduced water, gypsum dissolves, which can result in void creation and micro-piping in soil and enlargement of openings in gypsum-filled fractures. Under load and in the presence of additional water, the weathered shale bedrock can recompress and cause ground settlement. A case history of this circumstance in recent land development in the Whitewater area was discussed in White and Greenman (2008).

REFERENCES

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White, J.L., and Greenman, C.A., 2008, Collapsible soils in Colorado: Colorado Geological Survey, Engineering Geology 14, 108 p.

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Map units

- Areas of landslides and potential instability
- Problematic soils prone to settlement
- Public areas exposed to rockfall hazards
- Problematic surficial rock and derived soils of the Morrison Formation
- Problematic surficial rock and derived soils of the Mancos Shale